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SURVIVAL RATE OF YOGURT CULTURES DURING PRODUCTIC AND STORAGE OF YOGURT ICE-CREAM

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Key words: yogurt cultures, yogurt ice-cream, *Lbs. bulgaricus*, *Str. thermophilus*.

The survival of yogurt cultures during manufacture and storage of yogı ice-cream (frozen yogurt) made industrially was studied. Freezing of yogurt mixtı did not change significantly the population of yogurt cultures. The number of viat cells decreased gradually during the storage at -25°C. The population of *Lbc. bulga cus* accounted from 7.1×10^6 to 2.9×10^7 CFU/g and of *Str. thermophilus* fro 1.5×10^6 to 1.1×10^8 CFU/g after ten months of storage.

INTRODUCTION

For decades now yogurt has enjoyed the reputation of a product with consi derable nutritive, dietetic and even therapeutic values. These values were confir med in numerous scientific studies performed both in vitro and in vivo [6, 8, 1(13, 14, 20, 26, 31-33]. The therapeutic and dietetic value of yogurt is mainly due t the presence of the large numbers of viable cells of lactic acid bacteria, playing a very adventageous role in the human intestinal tract [1, 2, 4, 8, 9, 21, 25, 27, 28, 32] Some strains of yogurt cultures exhibit strong antibacterial properties and protect the product against the development of pathogenic and saprophytic microflora having adverse technological effects [7, 8, 18, 22, 26, 29, 35].

The specific flavour and acidity of yogurt attracted only a few consumers. The marketing of flavoured yogurts greatly enhanced its consumption [15]. The most successful product is yogurt combining the sensory qualities of ice-cream with the nutritional, dietetic and therapeutic values of yogurt. Frozen yogurt exhibits a delicate, refreshing taste, and a soft, smooth and creamy consistence. As a healthy food, it is recommended for children, elders, dietitians, diabetics, as well as a supplementary diet in chemotherapy. Frozen yogurt appeared on the market of the USA and several countries of Western Europe by the end of the 1970s causing a great increase of its consumption. In the USA about 75% of ice-cream manufactures changed the production on favour of frozen yogurt. Ba-

sides the increased demand, this was largely brought by economical reasons [3, 11, 16, 17, 19, 24, 34].

The technology of two varieties of frozen yogurts has been developed in the Dairy Research Institute, Division in Olsztyn. One it is frozen soft serve yogurt which is made with Italian-type freezer, and another one is industrially manufactured hard frozen yogurt suitable for storage. An important problem is the survival rate of yogurt cultures during the manufacture and storage of yogurt ice-cream. Despite the great interest in frozen yogurt exhibited by researches, producers and consumers, the scientific literature offers only fragmentary information on this subject.

MATERIAL AND METHODS

Ten batches of hard frozen yogurt industrially manufactured with addition of various stabilizers and flavourings were studied. The yogurt mixture was frozen at about-6°C with the resulting ice-cream being packed and hardened at-30°C for 30 min. following the storage at -25°C.

The number of viable *Lbc. bulgaricus* and *Str. thermophilus* cells as well as pH were determined during production and after two, four, and ten months of storage of yogurt ice-cream. Cell numbers as colony form units (CFU) on the LAB medium was counted [5]. The relatively anaerobic conditions for growth on Petri dishes were secured by an additional ca. 0.5 cm. medium layer. The incubation was carried out for 72 h at 42°C. The colonies of the respective species were distinquished on the basis of morphology. The concentration of hydrogen ions was measured potentiometrically.

RESULTS

Changes in the number of yogurt cultures during manufacture and storage of yogurt ice-cream, and the range of the fluctuations for ten studied batches, are illustrated in Fig. The number of *Lbc. bulgaricus* CFU in milk after inoculation varied between the batches from 1.0×10^7 to 4.8×10^7 per cm^3; the respective figures for *Str. thermophilus* were 1.1×10^7 and 4.8×10^7. During incubation the populations of both bacteria species increased by one order magnitude on everage. Cell numbers increased further in smaller extent during yogurt maturing. Depending on the batch, in fully matured yogurt it was stated from 2.2×10^8 to 1.3×10^9 CFU/cm^3 of *Lbc. bulgaricus* and from 4.7×10^8 to 2.8×10^9 of *Str. thermophilus*. The introduction of flavour additivies to the yogurt led to a slight drop in the cell number of both species, still more evident for *Lbc. bulgaricus*. Homogenization of yogurt mixtures did not affect the bacteria populations. The strains showed a high survival rate during freezing and hardening of yogurt ice-cream. It was sta-

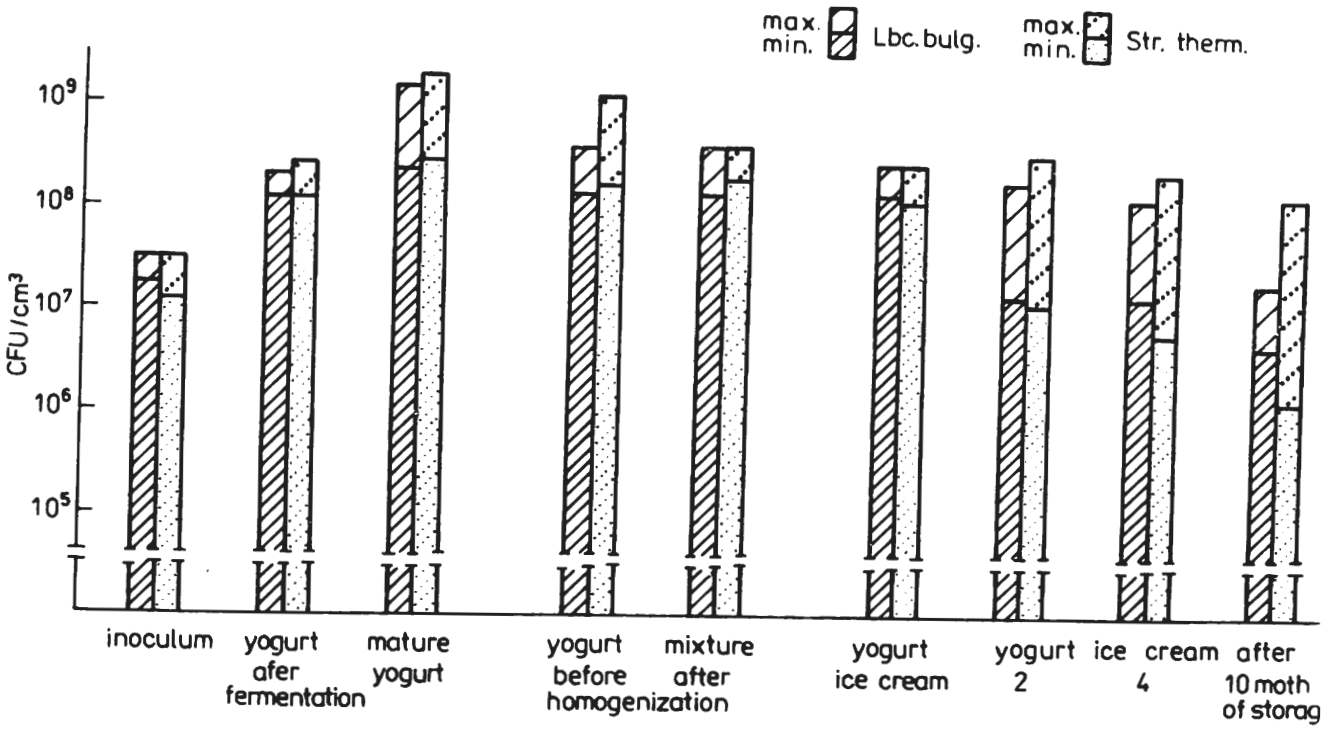

Fig. Changes in *Lbc. bulgaricus* and *Str. thermophilus* viable cell numbers during manufacture a storage of yogurt ice cream

ted from 1.8×10^8 to 4.7×10^8 CFU of *Lbc. bulgaricus* and from 1.0×10^8 4.6×10^8 CFU of *Str. thermophilus* per cm^3 of the final product. During stora the number of viable cells in yogurt ice-cream decreased gradually and account from 7.0×10^6 to 2.5×10^7 CFU of *Lbc. bulgaricus* and from 1.5×10^6 to 1.8×1 CFU of *Str. thermophilus* per cm^3 after ten months of storage.

Acidity of yogurt and yogurt ice-cream ranged from pH 4.2 to 4.5 and fro pH 3.9 to 4.2 respectively, remaining unchanged during storage (Table).

Table. The pH changes during manufacture and storage of yogurt ice cream

Stages of manufacture and storage	Batches									
	I	II	III	IV	V	VI	VII	VIII	IX	X
Inoculated milk	6.25	6.21	6.19	6.27	6.21	6.31	6.19	6.22	6.27	6.24
Yogurt after fermentation	4.82	4.91	4.85	4.75	4.80	4.93	4.71	4.76	4.84	4.91
Mature yogurt	4.54	4.49	4.51	4.43	4.27	4.21	4.37	4.42	5.51	4.53
Yogurt mixture	4.29	4.22	4.37	4.21	3.94	3.93	4.04	4.00	4.25	4.31
Yogurt mixture after homogenization	4.27	4.23	4.32	4.19	3.92	3.94	3.97	4.01	4.21	4.32
Yogurt ice cream	4.21	4.12	4.24	4.17	3.90	3.91	3.94	3.97	4.17	4.27
Yogurt ice cream after storage:										
2 month	4.12	4.08	4.22	4.15	3.92	3.91	3.93	3.94	3.13	4.24
4 month	4.17	4.09	4.23	4.16	3.91	3.90	3.95	3.96	4.10	4.20
10 month	4.10	4.01	4.21	4.14	3.90	3.90	3.91	3.96	4.10	4.21

DISCUSSION

The cultures used in the experimental manufacture of yogurt ice-cream survived the freezing and hardening of ice-cream. The population of the viable cells in the final product was close to that in yogurt. The cocci-bacilli ratios, close to one, remained unchanged during the processing or changed slightly on favour of the bacilli. It was stated only small differences in the population, within one order of magnitude, for the various batches.

The introduction of flavour additives led to a decrease a few times in lactic acid bacteria concentration due to dilution. It was found only slight inactivation of cells during freezing and hardening of yogurt ice-cream. This was undouptly due to the protective agents e.i. carbohydrates, proteins, emulsifiers and stabilizers, present in relatively high concentration in yogurt mixture.

Miles and Leeder [23] studied the effect of dextrose, saccharose, maize syrup and total solids concentration on the survival rate of yogurt cultures during freezing and storage, stated that saccharose followed by maize syrup were the most effective protective agents. Dextrose had no effect on the survival of yogurt cultures. *Lbc. bulgaricus* was generally more sensitive to both freezing and high sugar concentration. After two weeks of storage at -28 9°C, the number of viable bacilli cells dropped by 1-2 orders of magnitude, and by one order of magnitude in the presence of saccharose or maize syrup of the concentrations up to 10 and 6% respectively. According to the authors, the higher content of total solids in yogurt favoured the survival of both yogurt cultures, especially of *Lbc. bulgaricus*.

The protective effect of relatively high concentrations of proteins and carbohydrates in yogurt mixture is minimized, at least partly, by lactic acid. However, the differences in the survival rate of yogurt cultures stated for the various batches were not strictly correlated with the acidity. The hydrogen ion concentration in all studied products was on a similar level (pH 3.9-4.2) and did not change during the storage.

The reduction of the population following gradually during the storage was pronounced mostly at the early stage. With the time passing, changes in the ratio of both yogurt cultures deepened, and differences in cells number between the various batches grew. *Lbc. bulgaricus* cells died more offen than did *Str. thermophilus*. The poorer survival of *Lbc. bulgaricus* compared with *Str. thermophilus* was observed also by Guirginov and Grouer [12] in yogurt stored at temperatures below and above 0°C. Speck and Geoffrion [30] stated a slight reduction in the number of yogurt culture, and no changes in lactase activity in frozen yogurt during two months storage at -16°C. At +1°C the activity of lactase decreased by about 50% with no much change in the population.

CONCLUSIONS

1. Freezing conducted under conditions for industrial manufacture of ice-cream does not cause the inactivation of yogurt cultures.

2. There is a small gradual reduction of *Lbc. bulgaricus* and *Str. thermoph* cells during storage of yogurt ice-cream.

3. Yogurt ice-cream may be stored for six months without significant los biological value.

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PRZEŻYWALNOŚĆ KULTUR JOGURTU PODCZAS PRODUKCJI I PRZECHOWYWANIA LODÓW JOGURTOWYCH

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Streszczenie

Lody jogurtowe łączą w sobie walory sensoryczne lodów oraz wartości odżywcze, dietetyczne i lecznicze jogurtu, uwarunkowane obecnością liczby żywych komórek korzystnych dla organizmu ludzkiego bakterii fermentacji mlekowej o właściwościach antybakteryjnych wobec wielu grup bakterii chorobotwórczych i saprofitycznych. Badania obejmowały określenie zmian liczebności populacji *Lbc. bulgaricus* i *Str. thermophilus* podczas przemysłowej produkcji lodów jogurtowych oraz po 2,4 i 10 miesiącach przechowywania. Początkowe liczby komórek w mleku po zaszczepieniu — rzędu $10^7/cm^3$ — wzrastały w czasie fermentacji o 1-2 rzędy wielkości, osiągając w jogurcie po dojrzewaniu wartości $2{,}2 \times 10^8$ do $2{,}8 \times 10^9$. Podczas produkcji i hartowania lodów jogurtowych następowało 2-5-krotne obniżanie liczebności populacji, a w czasie przechowywania stopniowe obumieranie komórek. Po 10 miesiącach przechowywania lody jogurtowe zawierały w 1 g $7{,}0 \times 10^6$ do $2{,}5 \times 10^7$ żywych komórek *Lbc. bulgaricus* i $1{,}5 \times 10^6$ do $1{,}8 \times 10^8$ *Str. thermophilus*. Kwasowość czynna jogurtu kształtowała się na poziomie wartości pH 4,2-4,5, a lodów jogurtowych 3,9-4,2 i nie zmieniała się w czasie przechowywania.